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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

FULL-SCALE HYDRODYNAMIC EVALUATION OF A MODIFIED NAVY J4F-2 AMPHIBIAN WITH A 0.425-SCALE XP5M-1 HULL BOTTOM

TED NO. NACA DE325

By Norman S. Land, John M. Elliott, and Kenneth W. Christopher

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

An investigation was made to evaluate the hydrodynamic qualities of a 0.425-scale model of the Navy XP5M-1 hull, which was installed on a modified Navy J4F-2 amphibian. Longitudinal and directional stability during take-off and landing, low-speed maneuverability, spray characteristics, and take-off performance were investigated. The behavior of the airplane in moderately rough water was also observed. The opinions of three pilots have been correlated with the data.

INTRODUCTION

An evaluation, using a flying test vehicle, of the hydrodynamic characteristics of two experimental types of hull bottom was requested of the NACA by the Bureau of Aeronautics, Department of the Navy. A Navy J4F-2 amphibian was chosen as the vehicle since it was the smallest multiengine airplane readily available. The airplane (BuAero. No. 32976) was furnished by the Bureau of Aeronautics and modified by the Edo Aircraft Corporation under contract to the Bureau of Aeronautics so that any of several hull bottoms could be installed. This paper describes the tests and presents the results obtained from a flight investigation of the hydrodynamic characteristics of the J4F-2 with a 0.425-scale bottom of the Navy XP5M-1 flying boat. The investigation was conducted at Langley Aeronautical Laboratory using the procedures described in reference 1 as a guide.

All of the regular flight tests were made by one NACA pilot. Two visiting pilots made one flight each to furnish additional opinions on the hydrodynamic behavior of the airplane. The over-all opinions of all three pilots were obtained for correlation with the data.

DESCRIPTION OF AIRPLANE

The airplane, as modified by the Edo Aircraft Corporation, incorporated a splice line in the skin and frames above the chines so that any of several hulls could be installed. Above this splice line the airplane had only minor modifications which resulted in a slightly reduced rudder area and a landing gear that retracted back and up under the wing instead of into the fuselage. Photographs of the modified airplane and the standard J4F-2 airplane are shown as figures 1 and 2. A three-view drawing is shown in figure 3 and the pertinent dimensions are listed in table I. A lines drawing of the hull is shown in figure 4.

The most important feature of the hull was its long afterbody which had a length-beam ratio of 4.9. This afterbody had a warped bottom with an angle of deadrise of 20° at the step and sternpost and a maximum angle of deadrise of 44° at approximately 54 percent of its length. The step had a vee plan form with a 60° included angle, and a depth of 5 percent of the beam at the keel.

The plating of the forebody bottom was not flat but was dished in approximately 1/16 inch between frames, thus forming a series of shallow waves. The airplane was received and tested in this condition.

The fore and aft location of the center of gravity of the airplane was adjustable by means of a liquid ballast system. This system consisted of two tanks, one located forward and one aft, and a transfer pump to shift the liquid. The level of the liquid in the forward tank, which was used to determine the center-of-gravity location, was shown by an indicator on the observer's panel. Ethylene glycol was used for the ballast liquid. With the airplane loaded for a test, the available center-of-gravity range was from 18 to 31 percent of the mean aerodynamic chord.

The following control-surface deflections were available: elevators 30° up to 20° down, rudder 28° right or left, and flaps 0° to 40° down.

The engines were Ranger six-cylinder, inline, air-cooled engines with a take-off rating of 200 horsepower each. The propellers were Beech two-blade, controllable-pitch, wooden propellers, $85\frac{1}{2}$ inches in diameter.

The gross load at the start of each flight was 5230 pounds. Decrease in gross weight during the flight due to consumption of gasoline and oil was never greater than 200 pounds, or 4 percent of the starting weight. The gross load of 5,230 pounds corresponded to a gross load coefficient C_{Δ_o} of 1.07 $\left(\text{where } C_{\Delta_o} = \frac{\Delta_o}{wb^3}\right.$ and Δ_o is gross load in pounds; w is specific weight of water in pounds per cubic foot; and b is maximum beam in feet$\left.\right)$ and a full-size gross load for the XP5M-1 of 68,100 pounds. At this gross load, the scaled-up wing loadings and power loadings of the J4F-2 compare with those of the XP5M-1 as follows:

	J4F-2	XP5M-1
Wing loading, lb/sq ft	50.4	48.5
Power loading, lb/hp at getaway	8.5	12.6
Power loading, lb/hp static	9.5	12.6

Thus, although the bottom of the hull of the modified J4F-2 was a scale model of the bottom of the XP5M-1, the wing loading at the test gross load was 4 percent greater than that corresponding to the XP5M-1 and the power loading was 25 to 32 percent less.

INSTRUMENTATION

The instrumentation was substantially the same as that used for previous investigations of the hydrodynamic characteristics of flying boats. Airspeed, waterspeed, elevator and rudder deflection, revolutions per minute of each engine, and time were recorded on the NACA events recorder. An NACA three-component linear recording accelerometer with a natural frequency of approximately 15 cycles per second was used on a few flights. In addition, trim and time were recorded on a modified gyro taken from a C-1 vertical-flight autopilot.

The following special indicating instruments were also used: an NACA optical trim indicator, elevator-deflection indicator, waterspeed indicator, and a ballast-location indicator. The available flight instruments were: sensitive airspeed indicator, sensitive altimeter, rate-of-climb indicator, turn-and-bank indicator, directional gyro, and artificial horizon.

The locations of the instruments in the airplane are shown in figure 5.

PROCEDURE

The hydrodynamic qualities of the airplane were determined by following the procedures outlined in reference 1 as closely as possible. The test runs were made in the waters adjacent to the Langley Air Force Base. A total of 16 flights were made, 11 of which provided data on stability, maneuverability, or spray. The remainder were either discontinued because of mechanical difficulty or consisted of waterspeed calibration runs. The average wind velocity for the smooth-water tests was approximately 9 miles per hour, with a high of 16 miles per hour at the end of one flight, and a low of 2 miles per hour at the beginning of another.

Take-off stability.- The take-off stability was investigated at center-of-gravity locations of 20, 25, and 30 percent mean aerodynamic chord, and with flap deflections of 0° and 20°. Trim limits of stability were determined in the usual manner, that is, by taxying at various constant speeds and increasing or decreasing trim until porpoising started. The upper limit, decreasing trim, was not obtained, as it was believed to be unsafe to let the amplitude of porpoising build up before recovery was made.

Fixed-elevator take-offs were made to define the elevator and center-of-gravity limits of stability. These take-offs were made with wide-open throttles and the propellers at the lowest available pitch. The observer held the control column and attempted to maintain a constant elevator deflection throughout the take-off by reference to the elevator-deflection indicator. This deflection was maintained after getaway until the pilot took over control of the elevators. Take-offs were discontinued if, at high speeds, the trim became as low as 2° and was still decreasing. Various elevator settings were used at each center-of-gravity position and flap deflection to define the limits of operation.

Landing stability.- Insofar as possible, landings were made with no final flare, that is, at a constant trim and a constant rate of descent of approximately 200 feet per minute. The available landing trims, using this procedure, were limited to a narrow range. The maximum landing trim was approximately 8°, at which trim the airplane was on the verge of stalling. The minimum landing trim of approximately 3° was limited by the landing speed and the rate of descent, neither of which could be excessive for reasons of safety. To obtain data at higher landing trims, normal piloting technique was used with a flare out before contact. Power was cut at or before contact, and, if possible, the elevator deflection at contact was maintained during the high-speed portion of the runout. Landings were made with flaps deflected 0° and 20°, and with center-of-gravity locations of 20, 25, and 30 percent mean aerodynamic chord.

Low-speed maneuverability.- As an indication of the maneuverability on the water at low speeds, the time to make 360° turns was measured. These turns were made with the rudder hard over, aiding the turn, inner engine idling, and with various amounts of power from the aiding engine.

RESULTS AND DISCUSSION

Take-off stability.- The trim limits of stability are shown in figure 6 for flap deflections of 0° and 20°. Data were not obtained beyond 80 feet per second, although normal getaway speeds were much higher. At 80 feet per second the lower limit of stability was below 2° trim and the pilot reported a tendency to yaw in this region. The determination of the lower limit of stability at higher speeds was therefore not considered advisable. An arbitrary limit of 2° trim at high speeds was set as a minimum for safe operation for the remainder of the investigation. The upper trim limit of stability was not determined at higher speeds because the light load on the water made the determination very difficult.

During the take-off runs, porpoising was found to be only one of the limitations on elevator deflection and center-of-gravity position for satisfactory take-off characteristics. These limitations are best illustrated by the trim tracks shown in figure 7 for typical take-offs with three different elevator deflections. With a small up-elevator deflection of -3°, the take-off was stable until, at high speeds, the trim penetrated the lower trim limit of stability, and porpoising of 3° amplitude occurred. At this low trim the directional stability became marginal and the run was discontinued. All of the low-angle porpoising encountered on fixed-elevator take-offs occurred at high speed. The lower-limit porpoising which is usually observed just above hump speed on most flying boats was not encountered with any elevator setting used. At an intermediate elevator deflection of -6°, the take-off was free of porpoising, although there was some upward pitch after getaway. With the greatest up-elevator deflection (-12.5°) shown in figure 7, high-angle porpoising of 4° amplitude occurred and an abrupt and objectionable upward pitch was encountered immediately after getaway.

The limitations on elevator deflection are further illustrated in figure 8 where the range of stable elevator deflection available to the pilot is shown throughout the entire take-off speed range at a given flap setting and center-of-gravity location. At low speeds, any elevator setting was permissible as no longitudinal instability was encountered within the complete range of available elevator deflection. At intermediate speeds, the useful elevator deflections were limited by porpoising at high or low trims. At speeds near getaway, the elevators had to be

above a minimum value to avoid either low trims or lower-limit porpoising. The elevators had to be below some maximum at getaway to avoid a sharp upward pitch which could easily lead to a stall.

The limiting elevator deflections for fixed-elevator take-offs were determined from the data shown in figure 9 (maximum amplitude of porpoising), figure 10 (minimum trim beyond hump speed), and figure 11 (angular velocity after getaway). Elevator deflections limited by porpoising were determined by applying the usual criterion of 2° allowable maximum amplitude of porpoising to the faired data of figure 9. During the tests the pilot and observer noted that this magnitude of oscillation was not objectionable even for such a small airplane. The period of the porpoising oscillations averaged 1.6 seconds per cycle and ranged from 0.9 to 2.5 seconds per cycle. The accompanying accelerations were very low. The elevator deflections as limited by low trim at high speed were determined from the faired data of figure 10 by using the previously mentioned arbitrary limit of 2° minimum trim for safe operation. The elevator deflections limited by upward pitch at getaway were determined from a correlation of the faired data of figure 11 with the test pilot's comments, figure 12. Angular velocities greater than approximately 6° per second were in general considered undesirable by the pilot. The up-elevator deflection resulting in an angular velocity of 6° per second was accordingly judged to be the highest satisfactory elevator setting.

These limits for deflection of the elevator as determined by lower- and upper-limit porpoising (fig. 9), by low trims at high speeds (fig. 10), and by abrupt upward pitch at getaway (fig. 11), are plotted against center-of-gravity location in figure 13. This figure shows that porpoising did not limit the elevator range, but the range was limited by low trims at high speeds and by objectionable jump take-offs. The range of fixed-elevator deflections suitable for take-off is seen to be 5° or less.

The elevator settings suitable for flight just after take-off are also shown in figure 13. These control-surface deflections were considerably below those settings which are usable on the water. A large pull force was necessary while on the water to hold the elevators in the acceptable range. One pilot commented: "Transition from water to air was sluggish and pilot-impression is that he, personally, had lifted the airplane by main strength and had almost been unsuccessful."

Of the three pilots who submitted comments, two were of the opinion that satisfactory instrument take-offs could not be made. Two pilots summarized the longitudinal stability as fair; one rated it as poor. (See table II.)

Take-off performance.- An attempt was made to determine the effect of elevator deflection, center-of-gravity location, and flap deflection on the take-off performance by an analysis of records of fixed-elevator take-offs. The resulting data scattered rather badly in spite of an approximate correction for wind velocity. This scatter is believed to be due to the lack of adequate information on the wind and its effects, and unavoidable variations in propeller thrust. Take-off times ranged from 25 to 45 seconds. The average acceleration between hump speed and getaway was approximately 2 feet per second per second.

Two pilots rated the take-off time and distance as fair; the third considered them poor.

Landing stability.- The results of the landing investigation are summarized in figure 14 as a plot of the number of skips against landing trim for smooth-water landings. The single skip that was often observed appeared to be of no consequence as the amplitude of motion in trim was relatively small and, in general, the landing stability was considered satisfactory. No significant trends with landing trim or position of the center of gravity were noted.

The airplane had a tendency to trim down rapidly immediately after contact and required a rapid up-elevator movement to prevent the trim from becoming dangerously low. Occasionally this trimming down was accompanied by yawing. The tendency to trim down at contact was considered objectionable by all three of the pilots who flew the airplane. The time history of a typical landing (see fig. 15) illustrates this nosing-down tendency.

The three pilots believed that the hydrodynamic characteristics would permit satisfactory instrument landings.

Low-speed maneuverability.- The time to complete 360° turns is shown in figure 16. At the higher engine speeds there was no significant difference between turns made to the right or left. At low engine speeds, however, the data would seem to indicate an inherent tendency to turn right. Sufficient data were not obtained to definitely establish this tendency as the heading of the airplane relative to the wind at the start of the turn probably influenced the data. Regardless of this uncertainty, the time to complete a turn was long for all conditions that were investigated. Such a slow rate of turn might be expected with this long hull.

Two pilots considered the low-speed maneuverability on the water to be poor; one reported it to be good.

Directional stability.- The directional stability at a speed just beyond the hump and a speed near getaway is indicated in figure 17. The pilot never used left rudder during take-off. At a speed just beyond the

hump, it was necessary, in light winds, to use a large amount of right rudder and differential power. In strong winds, no differential power was required and less rudder deflection was needed. At high speeds, a few degrees of rudder were sufficient. On several take-offs, the pilot noted a strong tendency to waterloop at high speeds and at trims below 2°.

One pilot rated the directional stability and control fair, one rated them poor, and the third had no comment.

Spray characteristics.- Two typical spray photographs are presented in figure 18. Such photographs have been analyzed and the results are given in figure 19. The curves shown are drawn through the points representing the peaks of bow spray blisters at the various speeds. At low speeds, the pilot had no lateral control and the airplane heeled so that one or the other of the wing-tip floats was in the water. On the wing-high side no spray entered the propeller. On the wing-low side, although spray entered the propeller and struck the flap, this spray was considered moderate. The photographs of figure 18 show the difference in the spray on the two sides due to heel.

Rough-water behavior.- Although no extended investigation in rough water was intended, a few take-offs and landings were made in waves as a qualitative check on the airplane's behavior. The waves, which formed a confused pattern, were estimated by observers to be 18 to 24 inches high and 20 to 25 feet long with an accompanying maximum wind velocity of 23 miles per hour. Three landings were made, all on the verge of stall. The first, made into the waves, was quite severe with a maximum recorded normal acceleration of 2.5g which occurred on the first impact. A time history of some of the quantities recorded for this landing is given in figure 20. In addition, this figure indicates the peak positive values of normal acceleration due to impact. The other two landings, which were made parallel to the wave crests, were not quite so violent, the maximum recorded normal acceleration being 2.1g in each case and occurring on the first impact. Two successful upwind take-offs were made in the rough water; a time history of the elevator and rudder deflections and waterspeed and the corresponding peak positive values of normal acceleration due to impact are shown in figure 21 for one of these take-offs. Three other take-offs had to be abandoned because of severe bouncing. Take-off attempts made in a direction parallel to the wave crests resulted in especially large motions about all three axes because of the confused wave pattern and the short, steep waves. The airplane taxied well upwind and downwind, although the nose buried a few times on the upwind heading. Crosswind taxying caused the downwind tip float to bury. As the severity of the wind and waves was increasing throughout the flight, the airplane was finally taxied to quieter water for the final take-off. Inspection revealed severe damage to the left tip float,

moderate damage to the right tip float, the tail-wheel doors broken open, and moderate damage to the forebody bottom, sides, and frames just forward of the step. The decision was made to terminate the tests of the XP5M-1 hull at this point.

CONCLUDING REMARKS

Hydrodynamic qualities established in the flight investigation of the modified Navy J4F-2 airplane with the 0.425-scale XP5M-1 hull bottom may be summarized as follows:

1. The maximum up-elevator deflection usable for take-off was limited by abrupt pitch upward at getaway rather than by upper-limit porpoising.

2. The minimum up-elevator deflection usable for take-off was limited near getaway by directional instability at low trims rather than by lower-limit porpoising.

3. The take-off times ranged from 25 to 45 seconds. Between hump speed and getaway the average acceleration was approximately 2 feet per second per second.

4. No severe skipping on landing was encountered at any landing trim or center-of-gravity position in the operating range. There was, however, an objectionable tendency to trim down and yaw immediately after contact.

5. The rate of turn at maneuvering speeds was low.

6. During take-off in light winds a large amount of right rudder and differential power were required at speeds just beyond hump speed to maintain a straight course.

7. Spray struck the propeller and flap on the wing-low side during take-off but was clear on the wing-high side.

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REFERENCES

1. Parkinson, John B.: Appreciation and Determination of the Hydrodynamic Qualities of Seaplanes. NACA TN 1290, 1947.

TABLE I

PERTINENT DIMENSIONS FOR MODIFIED J4F-2 WITH

0.425-SCALE XP5M-1 HULL BOTTOM

General:	
Gross load, lb	5230
Total take-off horsepower	400
Wing loading, lb/sq ft	21.4
Take-off power loading, lb/hp	13.1
Hull:	
Maximum beam, ft	4.25
Length:	
Over-all, ft	36.82
Forebody, bow to step centroid, ft	16.08
Afterbody, step centroid to sternpost, ft	20.74
Step:	
Type	60°-Vee
Depth at keel, ft	0.21
Angle of forebody deadrise, deg	20.0
Maximum angle of afterbody deadrise, deg	44.0
Angle between forebody and afterbody keels, deg	8.0
Sternpost angle, deg	8.58
Wing:	
Span, ft	40
Area, sq ft	245
Root chord, ft	7.25
Root section, NACA	23,015
Tip chord, ft	3.62
Tip section, NACA	23,009
Mean aerodynamic chord (M.A.C.), ft	6.37
Incidence to forebody keel, deg	5.0
Flaps:	
Semispan, ft	11.7
Area, sq ft	31.2
Average chord, percent M.A.C.	25.8
Type	Slotted
Maximum deflection, deg	40
Horizontal tail surfaces:	
Area, sq ft	45.4
Span, ft	13.75
Mean aerodynamic chord (M.A.C.), ft	3.7

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TABLE I - Concluded

PERTINENT DIMENSIONS FOR MODIFIED J4F-2 WITH

0.425-SCALE XP5M-1 HULL BOTTOM

Ratio of elevator area to total horizontal tail area	0.43
Stabilizer incidence to forebody keel, deg	2
Tail length (25 percent M.A.C. of wing to 25 percent M.A.C. of horizontal tail), ft	16.0
Vertical tail surfaces:	
Area, sq ft	30.3
Span, ft	6.5
Mean aerodynamic chord (M.A.C.), ft	4.9
Ratio of rudder area to total vertical tail area	0.43
Tail length (25 percent M.A.C. of wing to 25 percent M.A.C. of vertical tail), ft	15.9
Propellers:	
Number	2
Number of blades	2
Diameter, ft	7.12
Distance of bottom of propeller arc above forebody keel at main step, ft	4.10
Distance of bottom of propeller arc forward of step centroid measured parallel to forebody keel, ft	6.32
Thrust axis inclination to forebody keel, deg	6.5
Wing-tip floats:	
Submerged displacement, lb	405
Distance from hull center line, ft	14.4
Angle of heel to submerge, deg	10.0

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TABLE II

TABULATION OF PILOTS' COMMENTS ON HYDRODYNAMIC QUALITIES OF

MODIFIED J4F-2 WITH 0.425-SCALE XP5M-1 HULL BOTTOM

Quality	Rating		
	Test Pilot	Pilot A	Pilot B
Take-off longitudinal stability and control	Control - fair Stability - poor	Control - poor Stability - fair	Control - fair Stability - fair
Landing stability and control	Fair	Fair	Good
Lateral stability and control	Fair	No comment	Poor
Take-off time and distance	Fair	Poor	Fair
Over-all rating on hydro-dynamic qualities	Fair to poor	Poor	Fair

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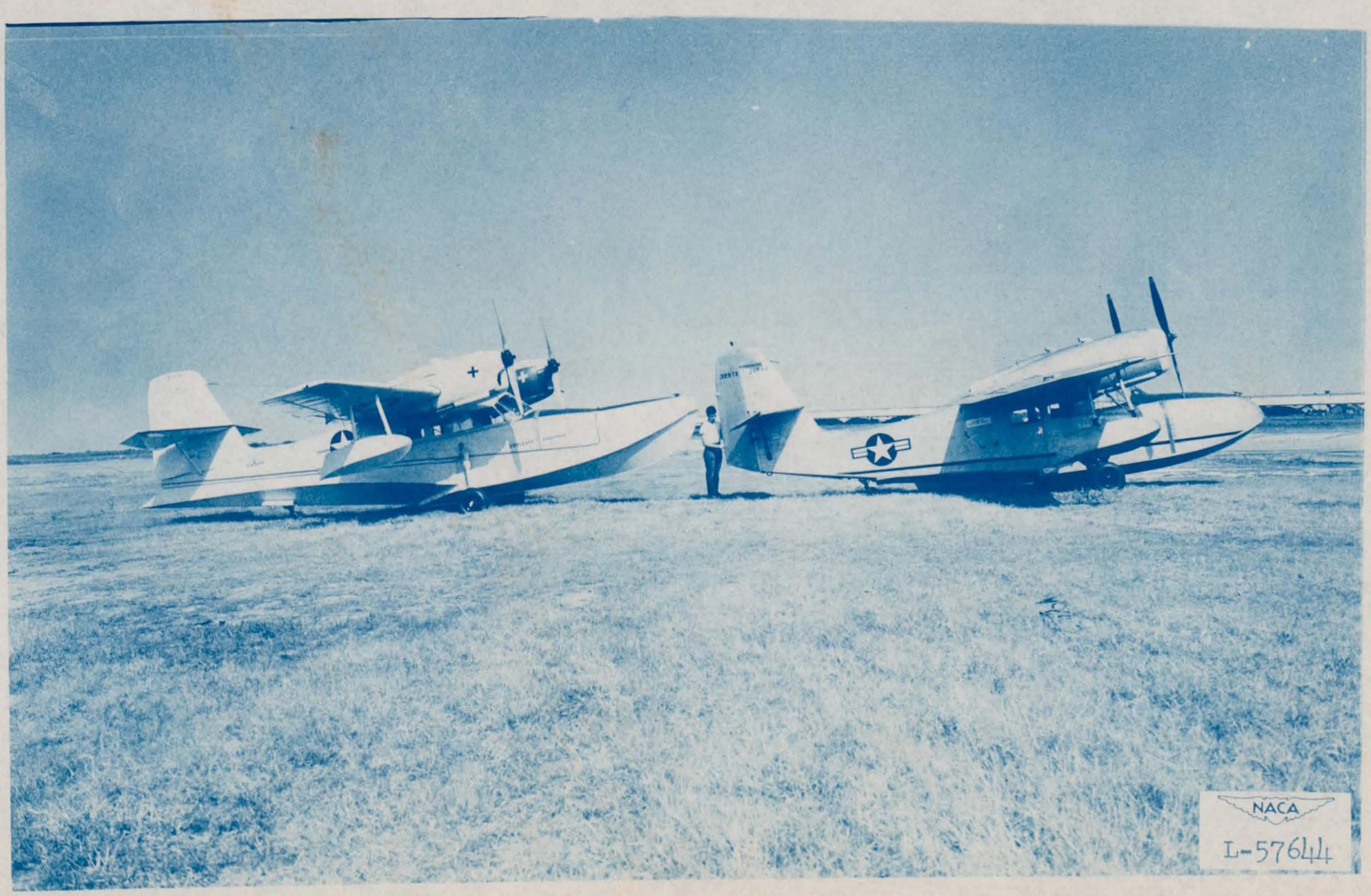

Figure 1.- Side views of J4F-2 with 0.425-scale XP5M-1 hull bottom and standard J4F-2.

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Figure 2.- Three-quarter front view of J4F-2 with 0.425-scale XP5M-1 hull bottom and standard J4F-2.

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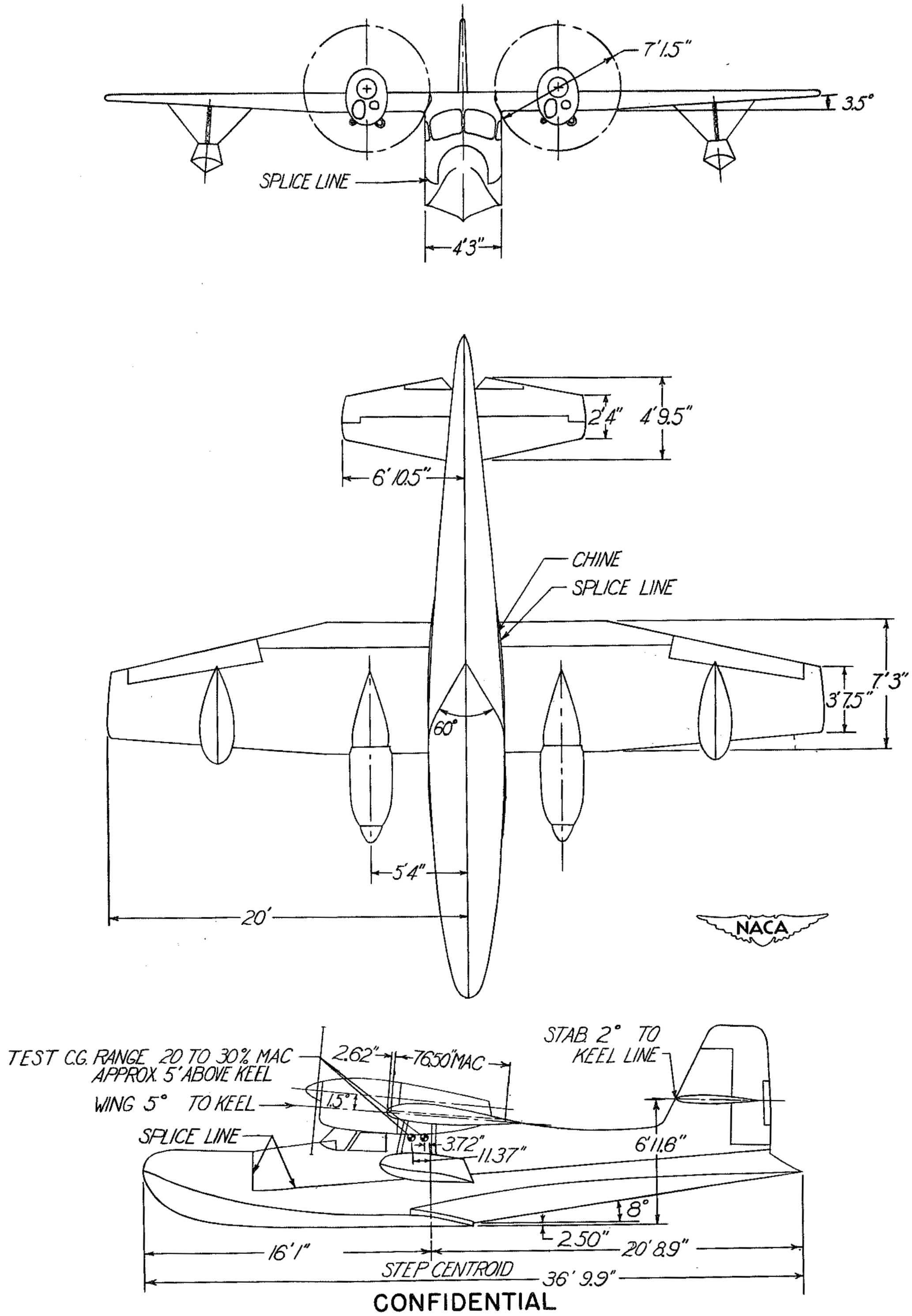

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Figure 3.- Three-view drawing of J4F-2 with XP5M-1 hull bottom.

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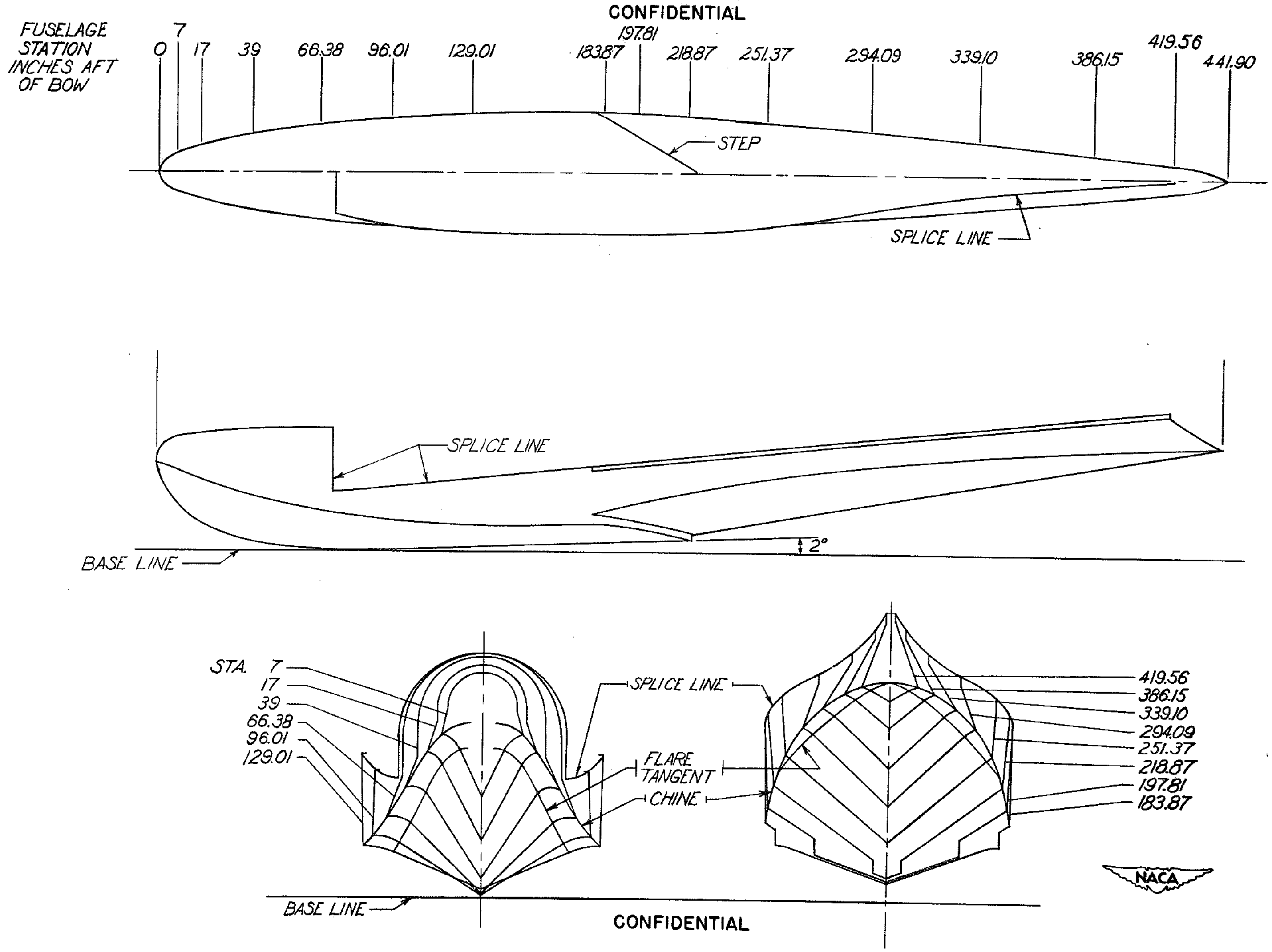

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Figure 4.- Hull lines of 0.425-scale XP5M-1 bottom as fitted to modified J4F-2.

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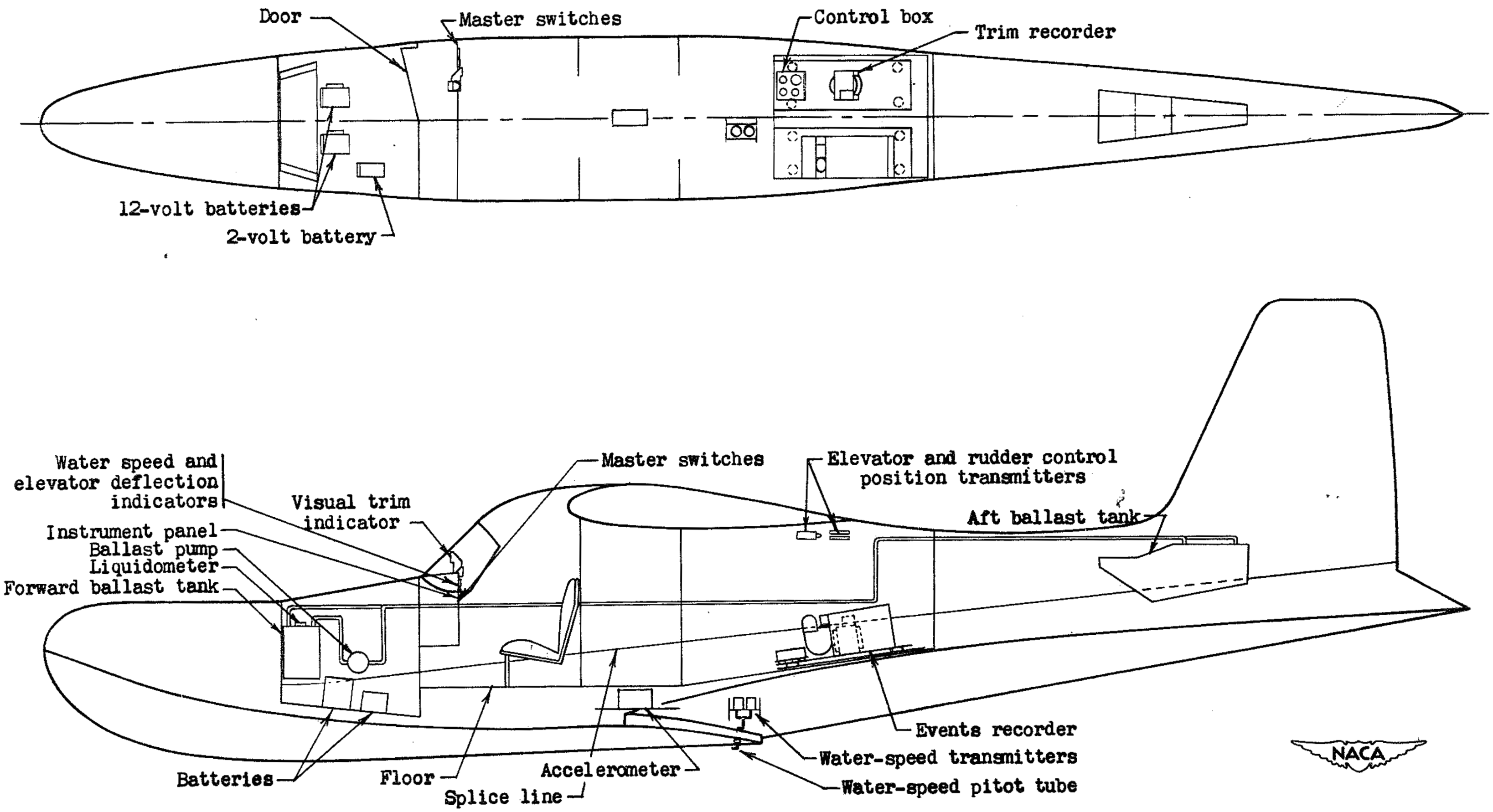

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Figure 5.- Location of instruments in fuselage of J4F-2 with XP5M-1 hull bottom.

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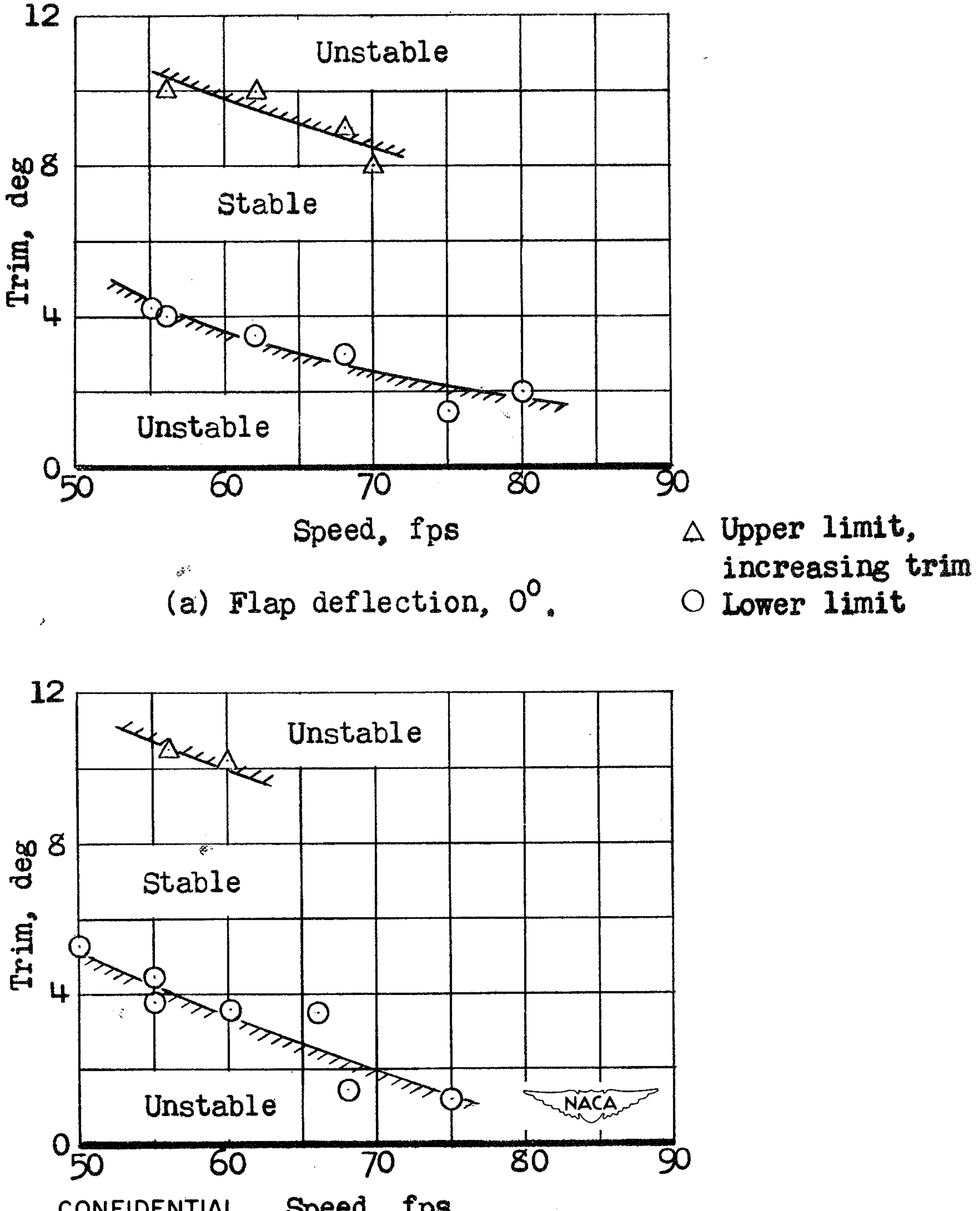

(a) Flap deflection, 0°.

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Speed, fps

(b) Flap deflection, 20°.

Figure 6.- Trim limits of stability.

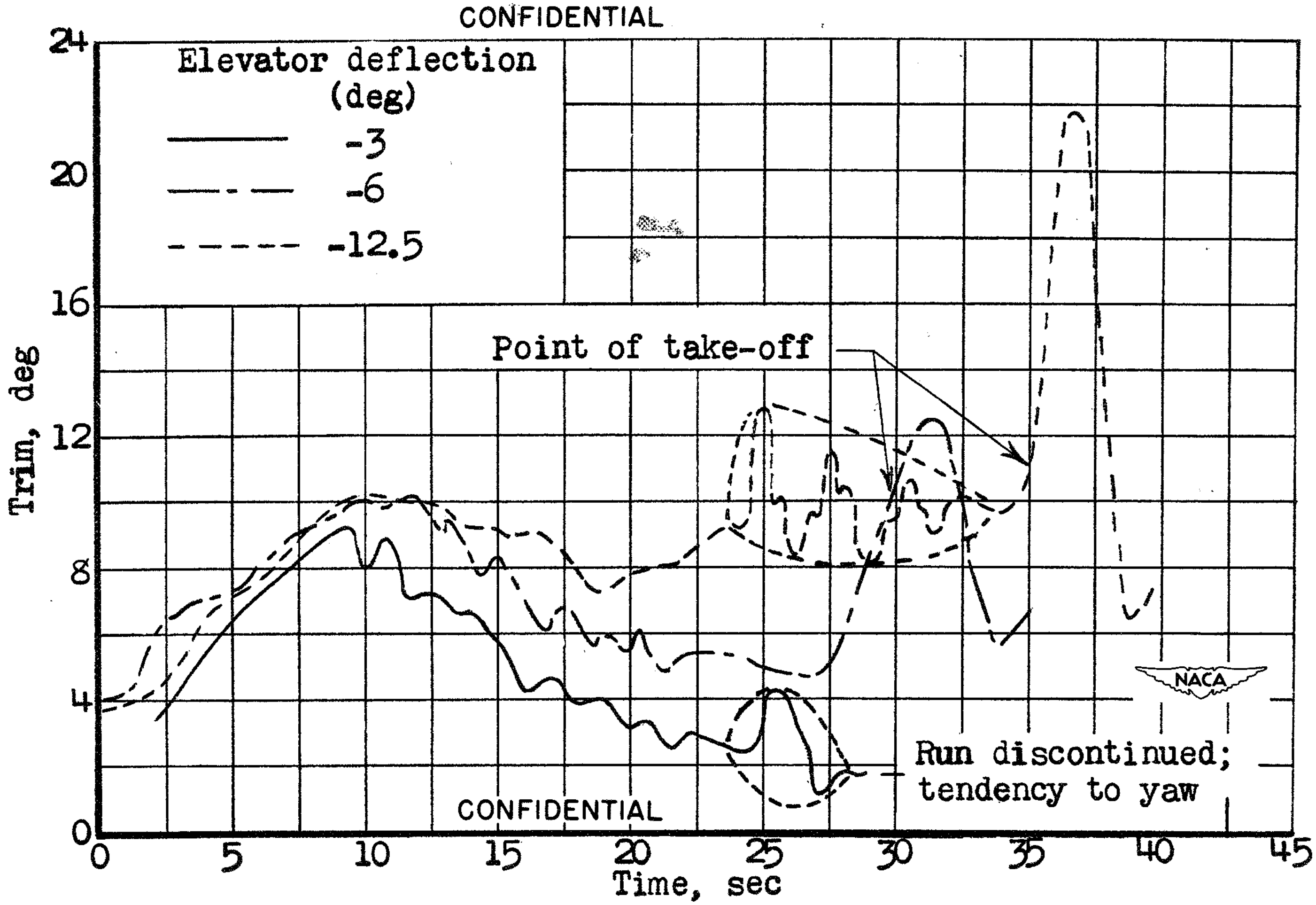


Figure 7.- Typical time histories of trim during take-off. Center of gravity, 25 percent mean aerodynamic chord; flap deflection, 0°.

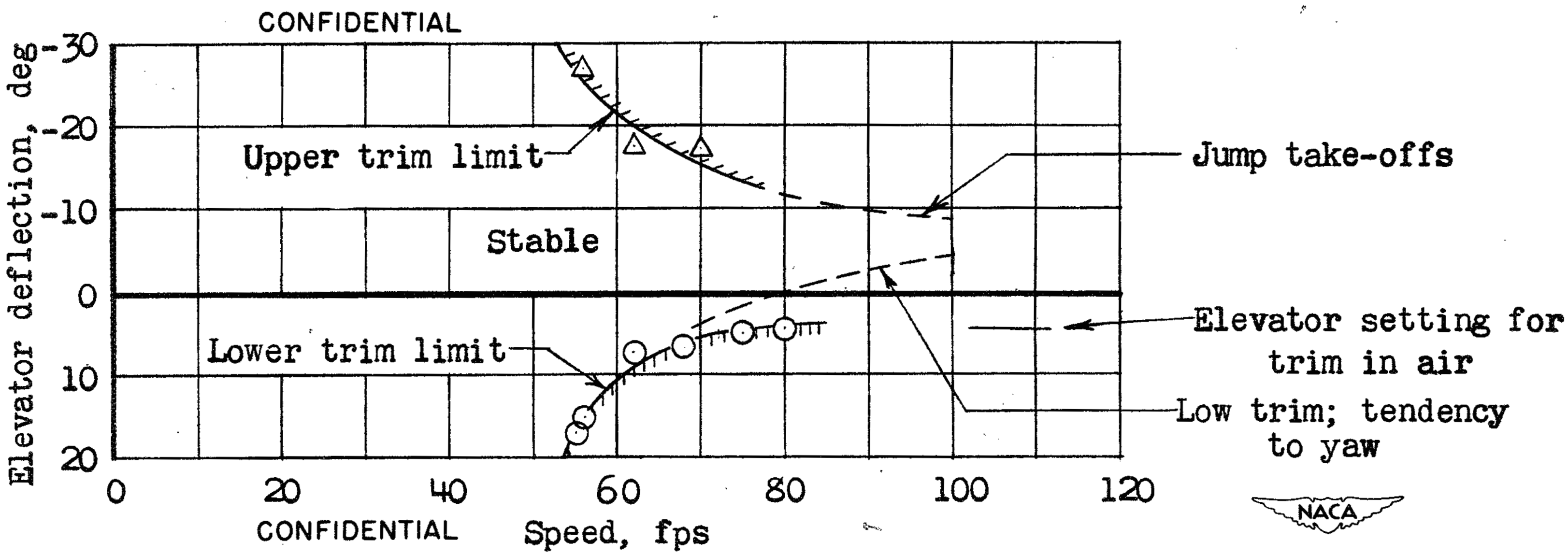
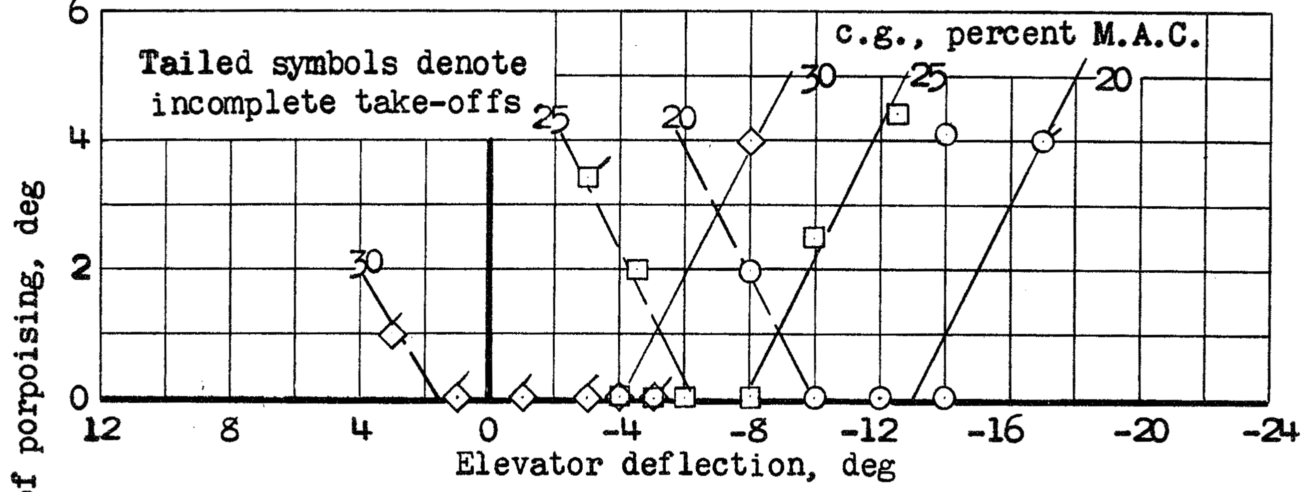
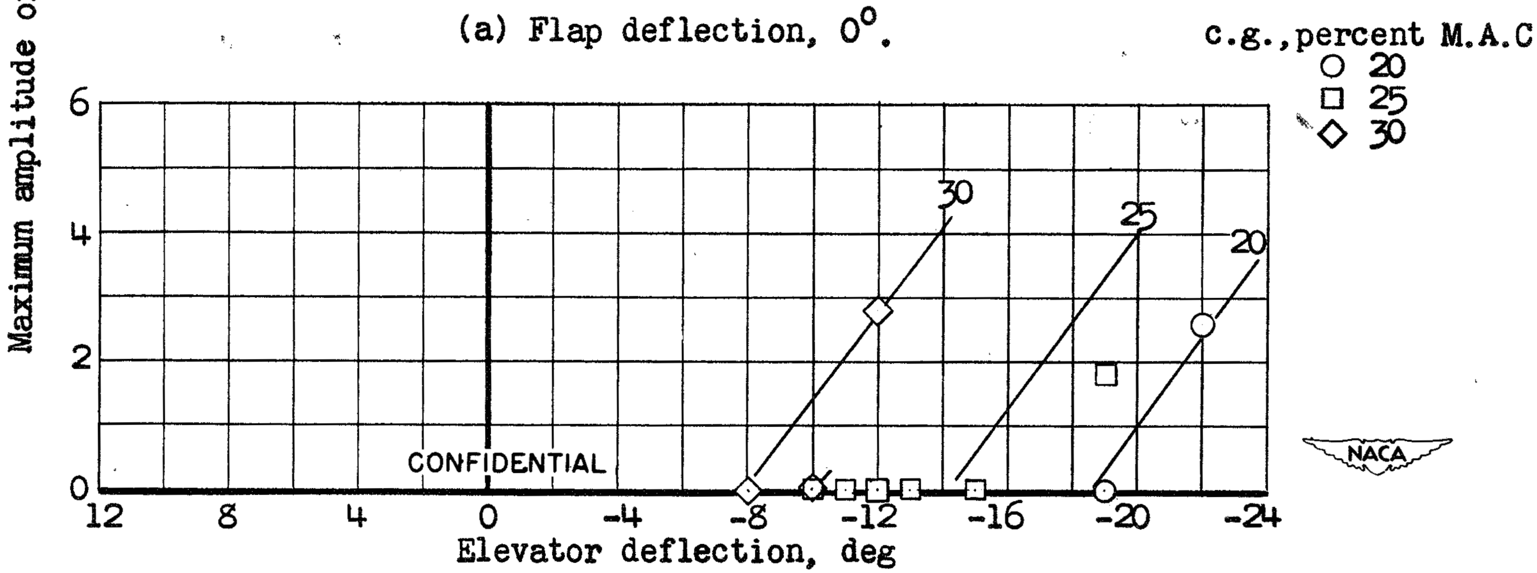


Figure 8.- Limits of usable elevator deflection throughout the speed range. Center of gravity, 25 percent mean aerodynamic chord; flap deflection, 0°.

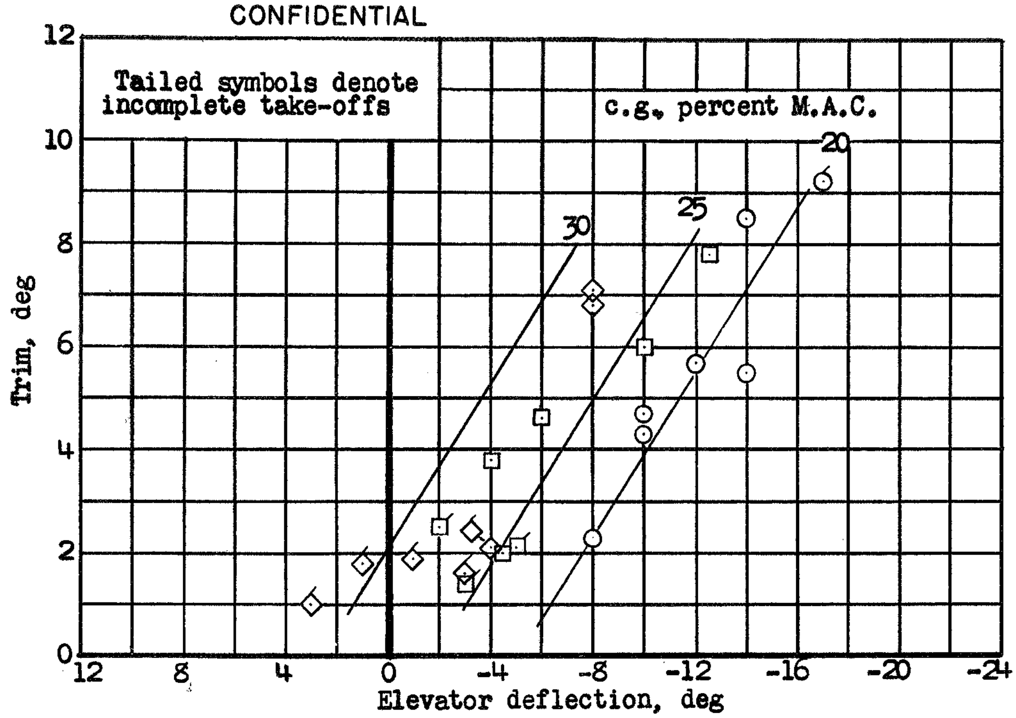


(a) Flap deflection, 0°.



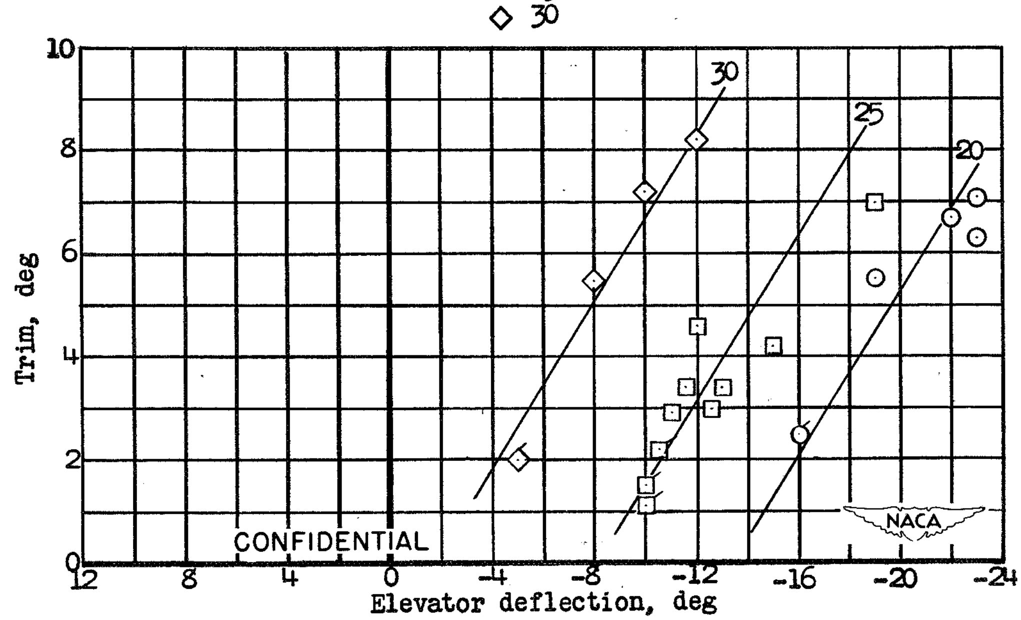
(b) Flap deflection, 20°.

Figure 9.- Maximum amplitude of porpoising during take-off.



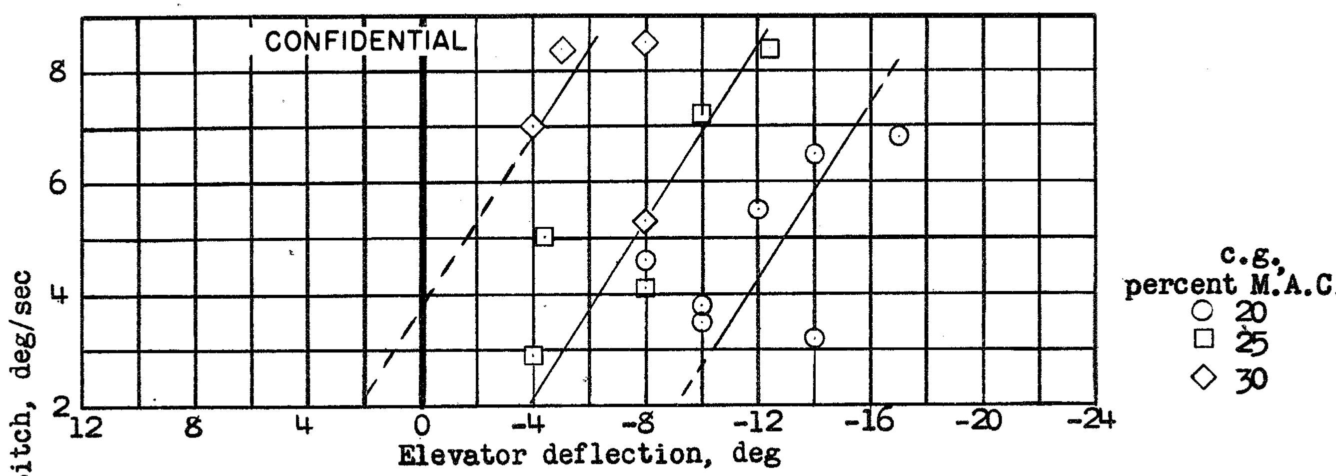
(a) Flap deflection, 0°.

c.g., percent M.A.C.
○ 20
□ 25
◇ 30

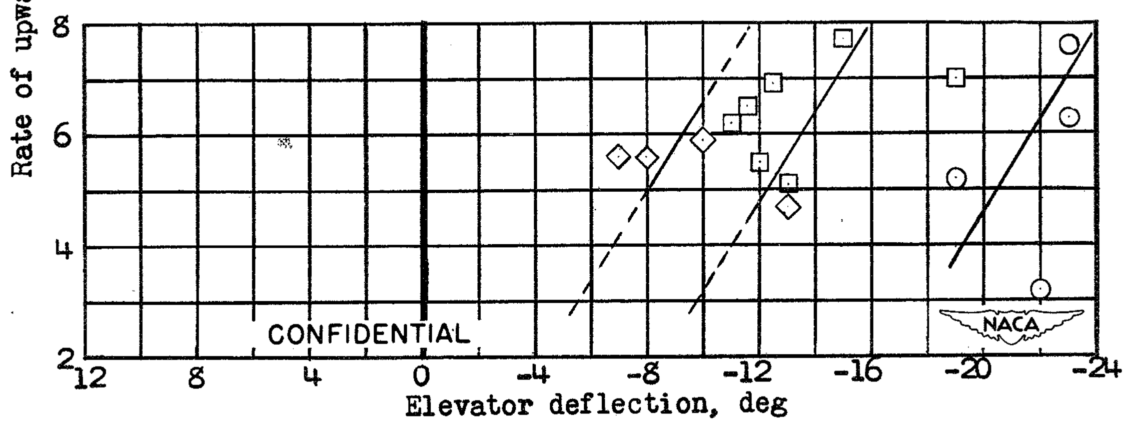


(b) Flap deflection, 20°.

Figure 10.- Minimum trim encountered beyond hump speed during take-off runs.



(a) Flap deflection, 0°.



(b) Flap deflection, 20°.

Figure 11.- Angular velocities occurring immediately after getaway.

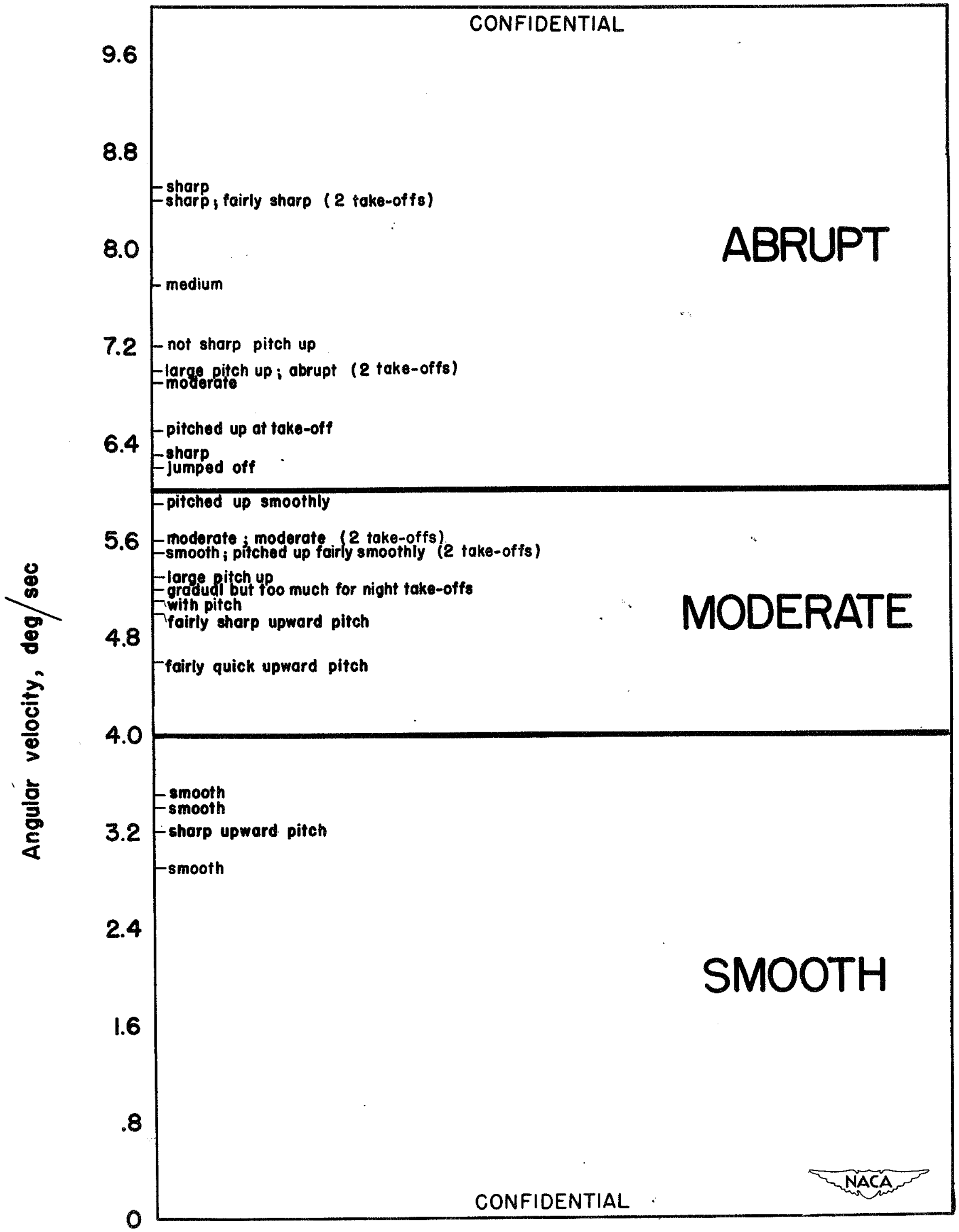


Figure 12.- Pilot's comments on pitch upward at take-off.

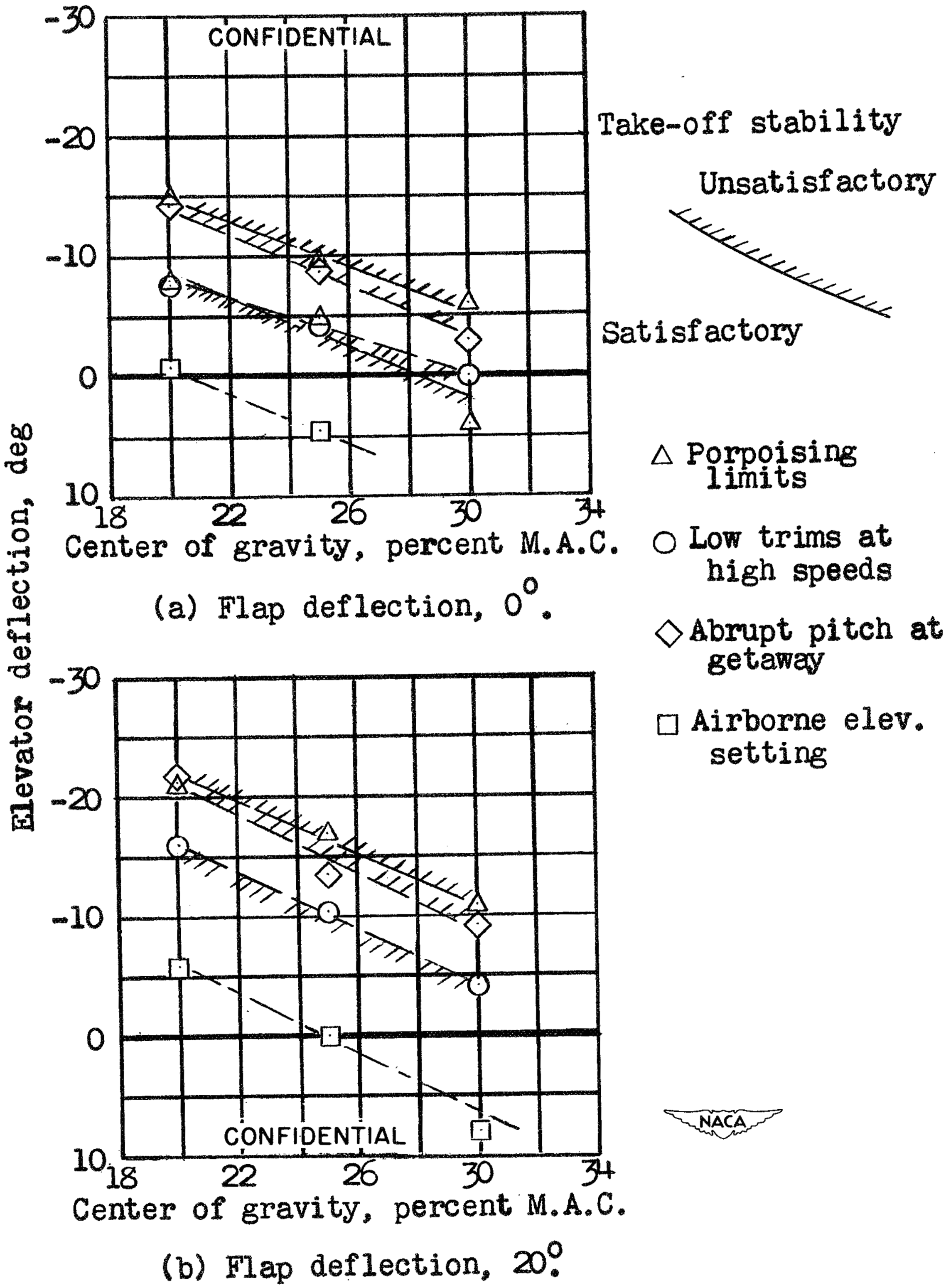


Figure 13.- Summary of take-off stability.

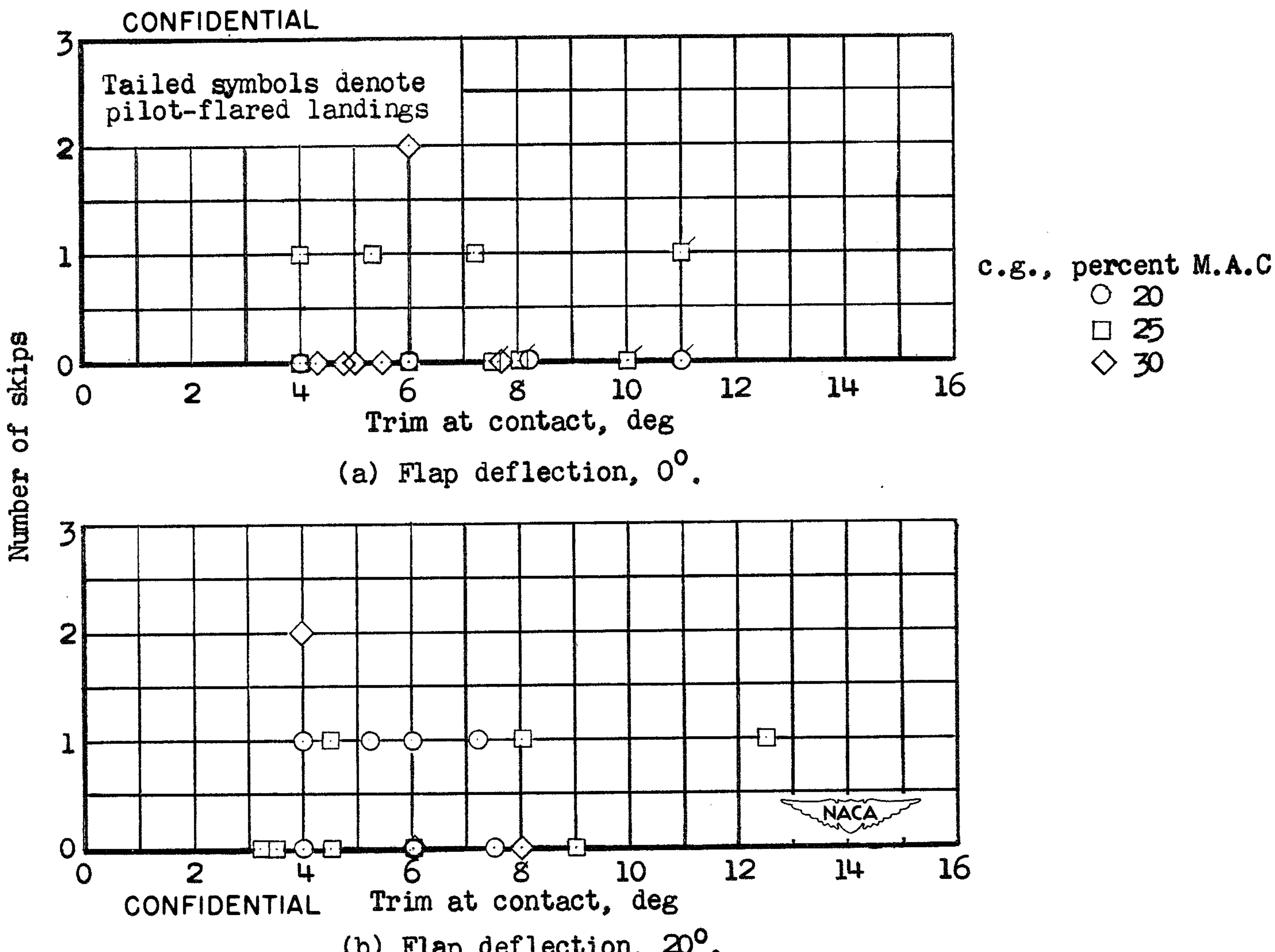


Figure 14.- Number of skips on landings in smooth water.

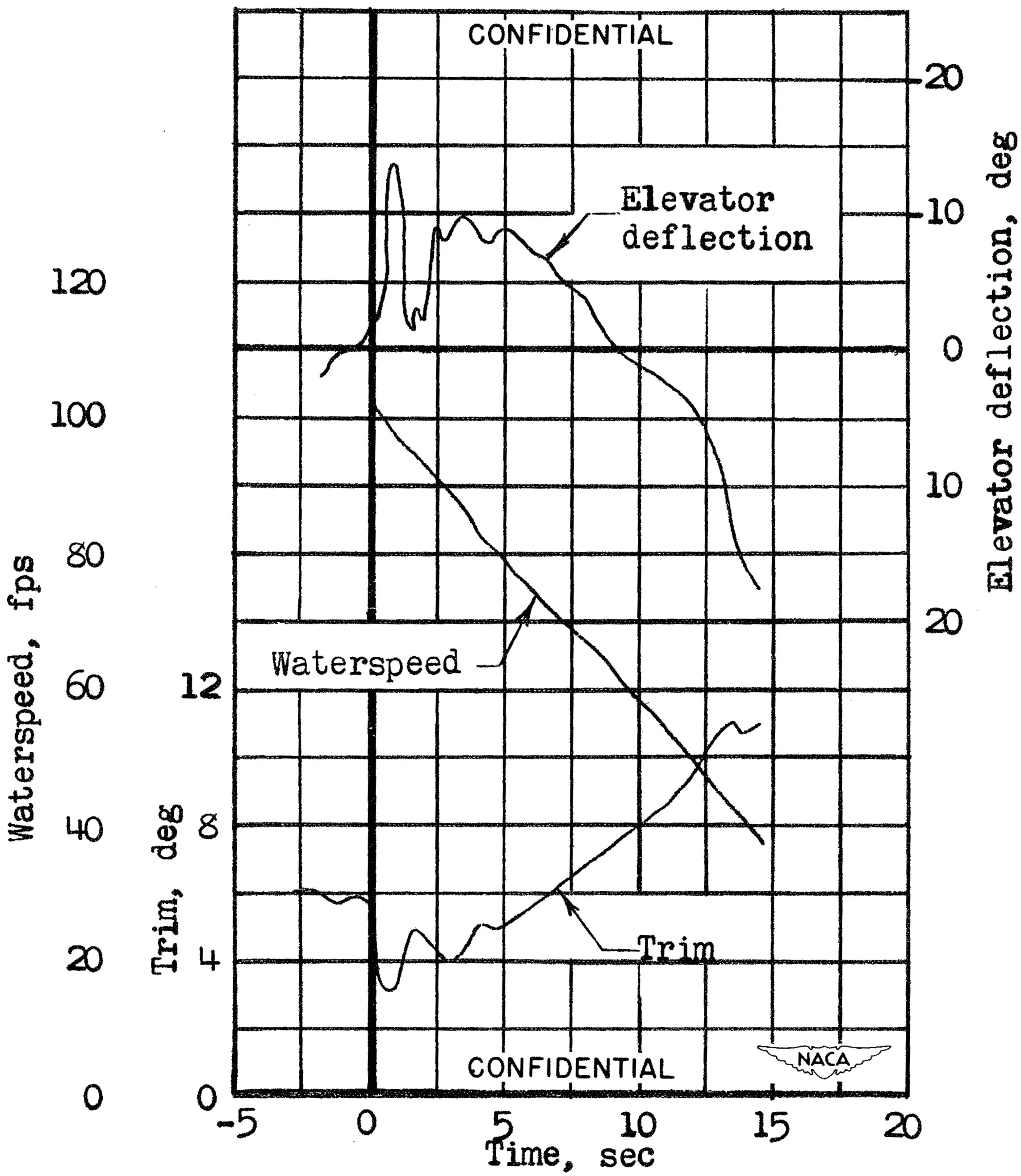


Figure 15.- Typical time history of a landing in smooth water.

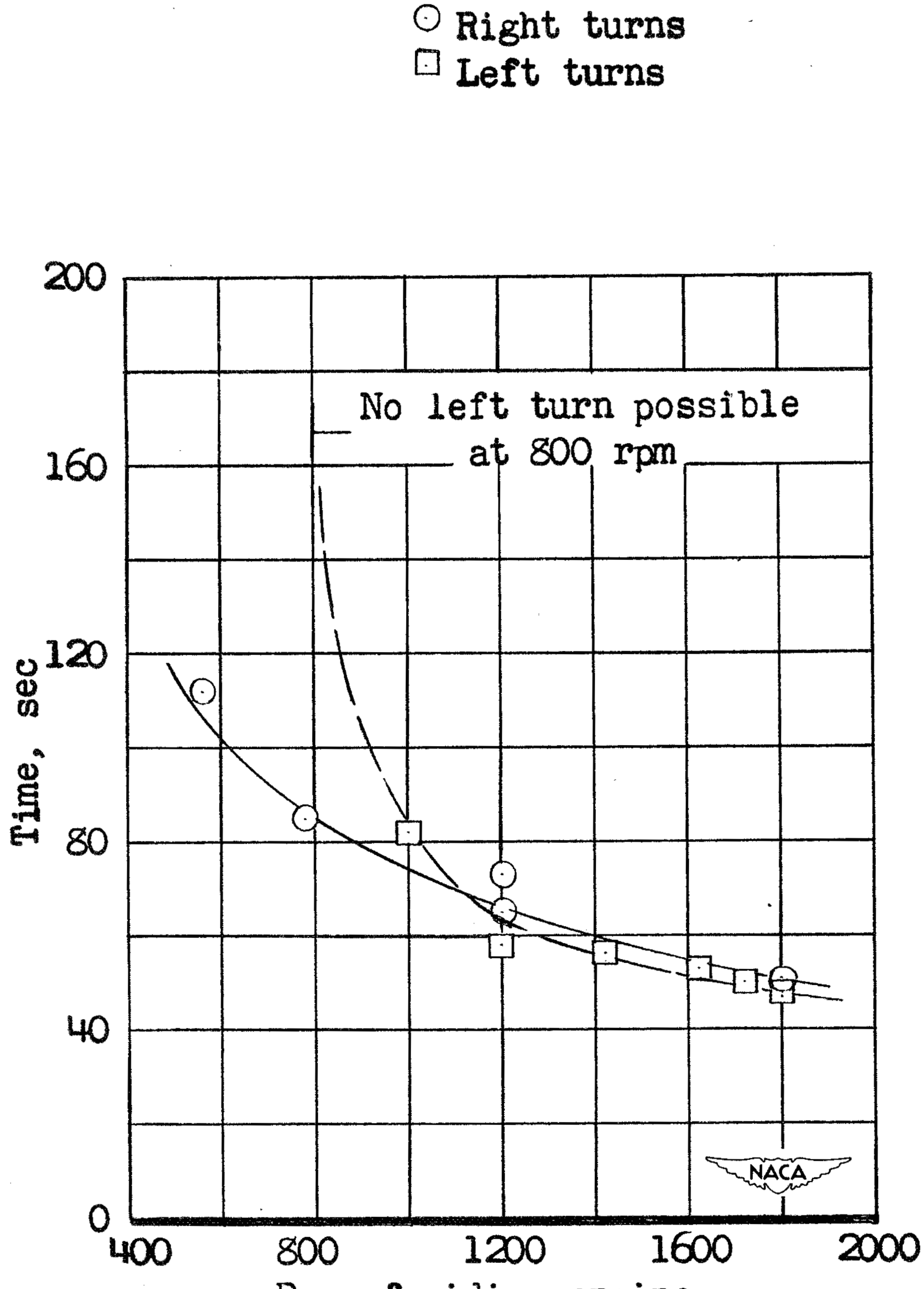


Figure 16.- Time to complete 360° turns at low water speeds.

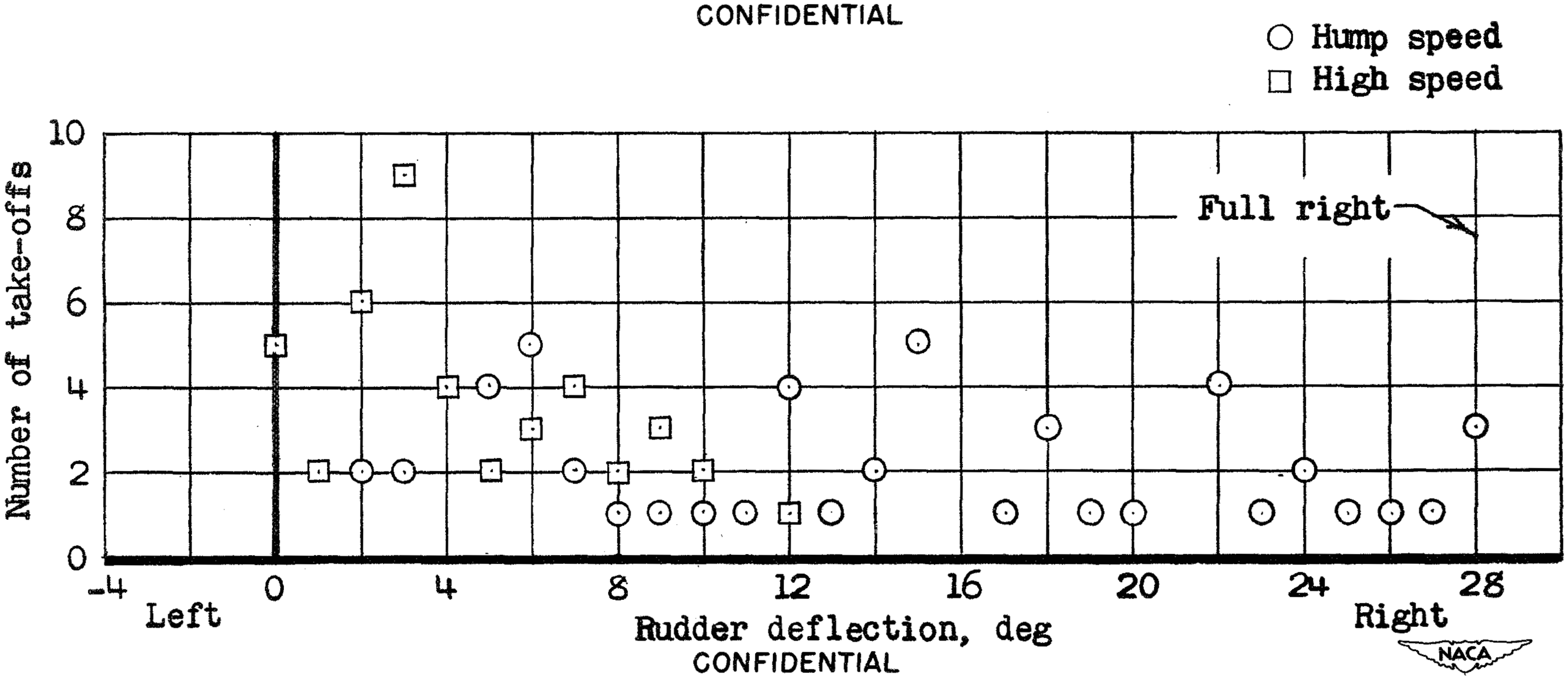


Figure 17.- Number of take-offs at which various rudder deflections were used at a speed just beyond hump and a speed near getaway.

(a) Wing-high side; center of gravity, 25 percent M.A.C.

(b) Wing-low side; center of gravity, 20 percent M.A.C.

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Figure 18.- Spray pictures. Speed, 19 feet per second; trim, 4.7°.

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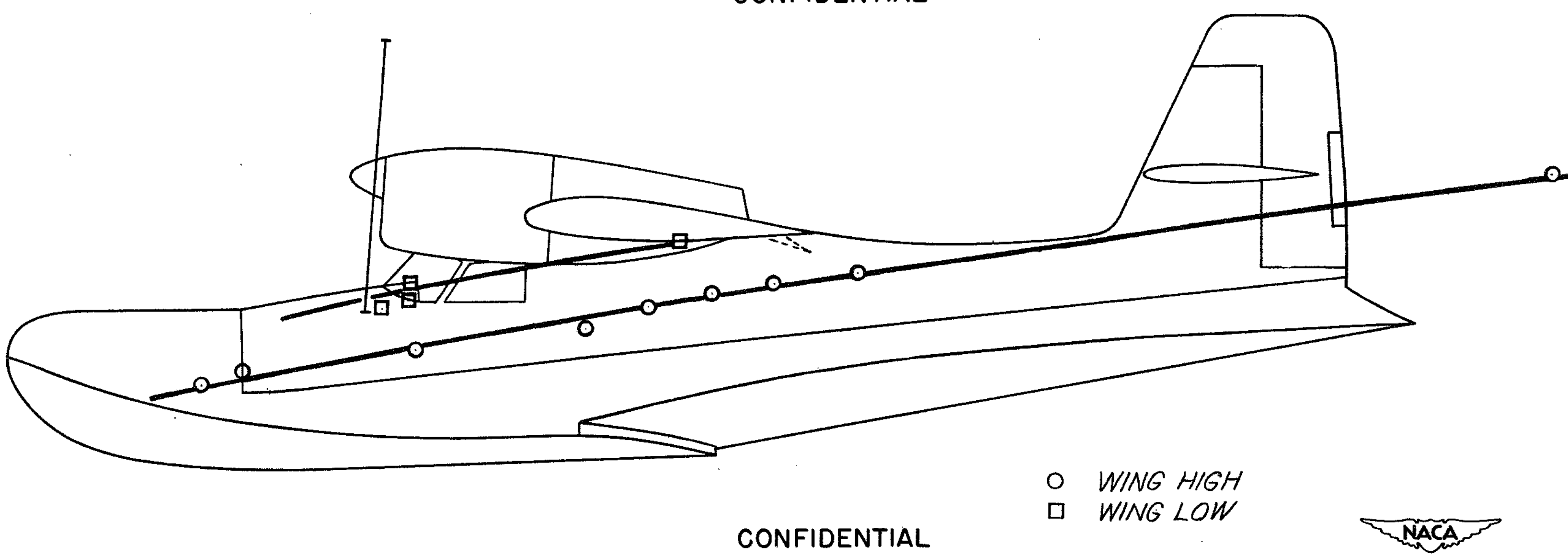

CONFIDENTIAL

Figure 19.- Main spray envelopes for J4F-2 with XP5M-1 hull bottom.

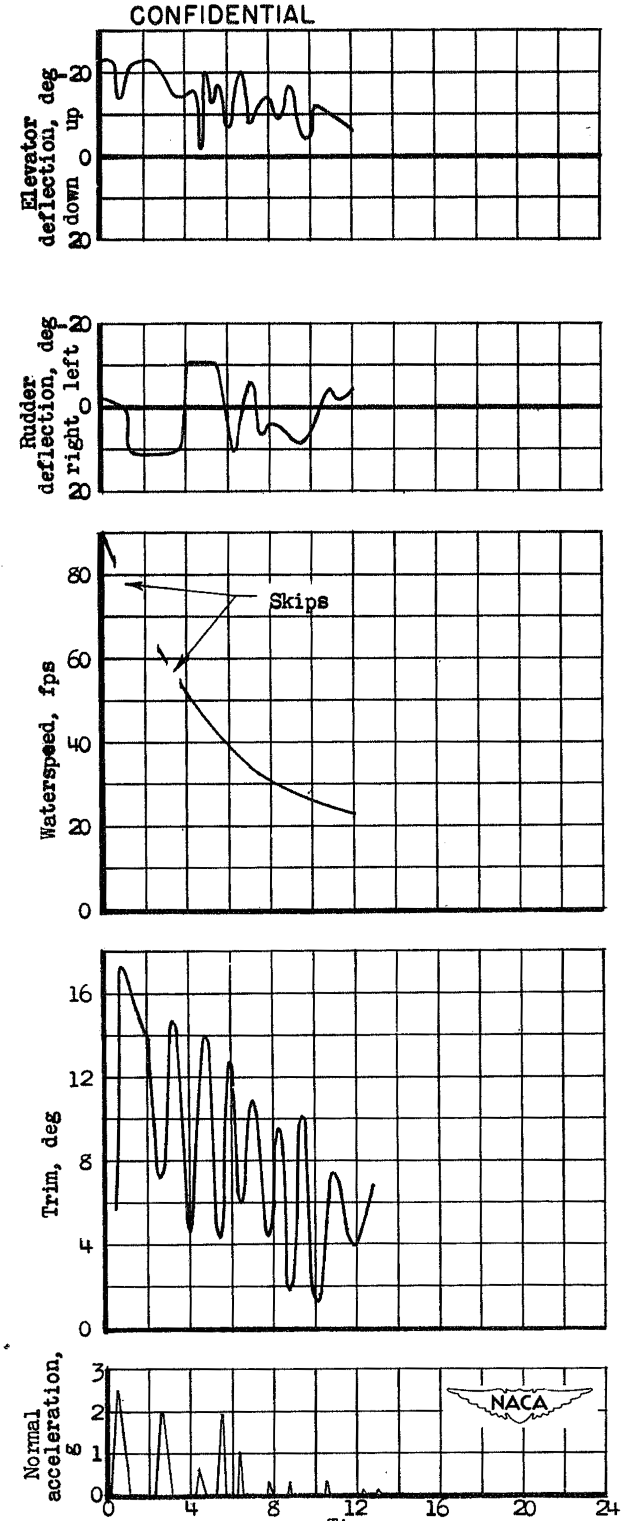

Figure 20.- Time history of a rough-water landing. Center of gravity, 25 percent mean aerodynamic chord; flap deflection, 20°.

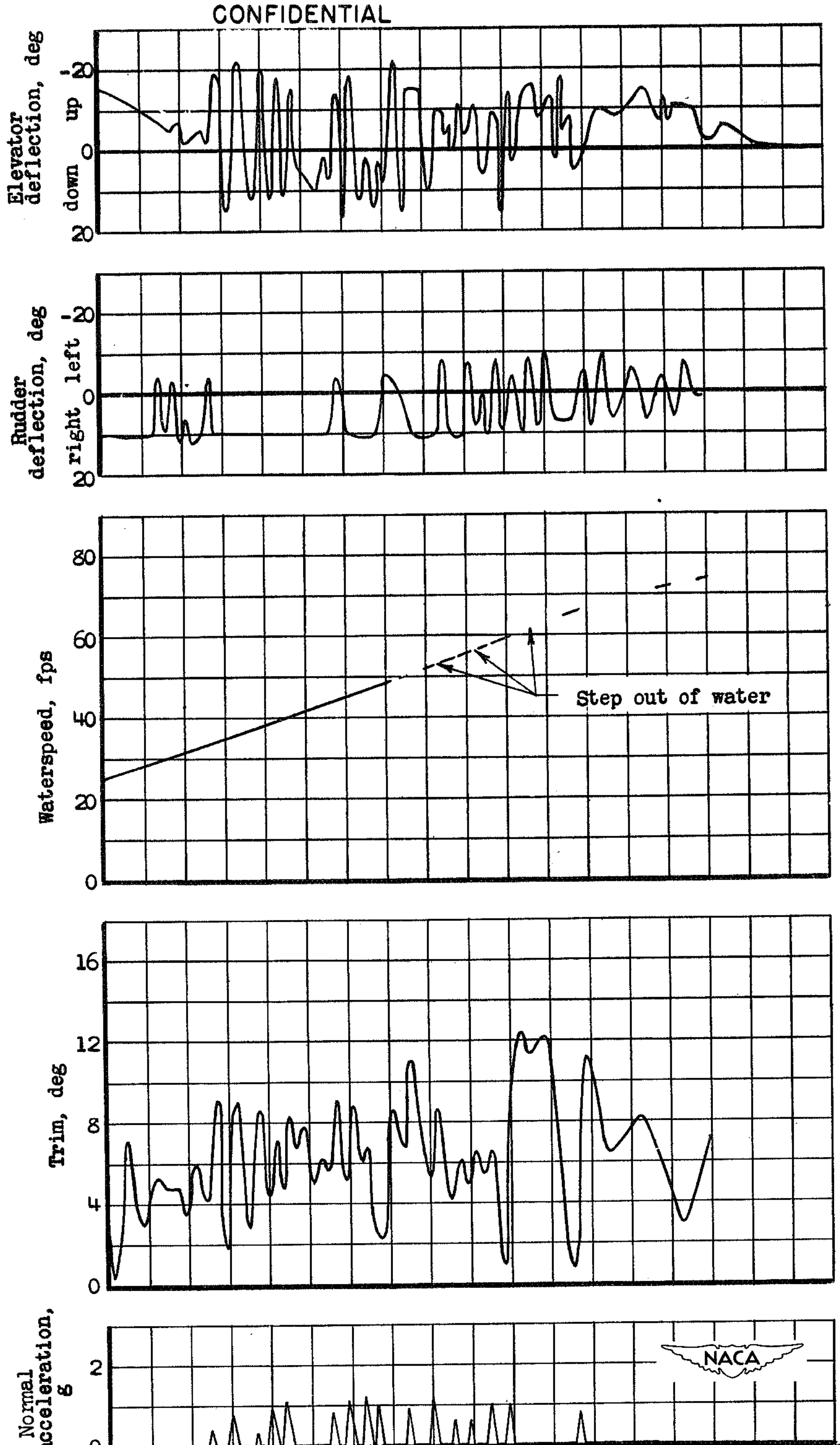

Figure 21.- Time history of a rough-water take-off. Center of gravity, 25 percent mean aerodynamic chord; flap deflection, 20°.

Superseded by Revised pages inserted to replace these 2-6-50

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

FULL-SCALE HYDRODYNAMIC EVALUATION OF A MODIFIED NAVY J4F-2 AMPHIBIAN WITH A 0.425-SCALE XP5M-1 HULL BOTTOM

TED NO. NACA DE325

By Norman S. Land, John M. Elliott, and Kenneth W. Christopher

SUMMARY

An investigation was made to evaluate the hydrodynamic qualities of a 0.425-scale model of the Navy XP5M-1 hull, which was installed on a modified Navy J4F-2 amphibian. Longitudinal and directional stability during take-off and landing, low-speed maneuverability, spray characteristics, and take-off performance were investigated. The behavior of the airplane in moderately rough water was also observed. The opinions of three pilots have been correlated with the data.

INTRODUCTION

An evaluation, using a flying test vehicle, of the hydrodynamic characteristics of two experimental types of hull bottom was requested of the NACA by the Bureau of Aeronautics, Department of the Navy. A Navy J4F-2 amphibian was chosen as the vehicle since it was the smallest multiengine airplane readily available. The airplane (BuAero. No. 32976) was furnished by the Bureau of Aeronautics and modified by the Edo Aircraft Corporation under contract to the Bureau of Aeronautics so that any of several hull bottoms could be installed. This paper describes the tests and presents the results obtained from a flight investigation of the hydrodynamic characteristics of the J4F-2 with a 0.425-scale bottom of the Navy XP5M-1 flying boat. The investigation was conducted at Langley Aeronautical Laboratory using the procedures described in reference 1 as a guide.

hump, it was necessary, in light winds, to use a large amount of right rudder and differential power. In strong winds, no differential power was required and less rudder deflection was needed. At high speeds, a few degrees of rudder were sufficient. On several take-offs, the pilot noted a strong tendency to waterloop at high speeds and at trims below 2°.

One pilot rated the directional stability and control fair, one rated them poor, and the third had no comment.

Spray characteristics.- Two typical spray photographs are presented in figure 18. Such photographs have been analyzed and the results are given in figure 19. The curves shown are drawn through the points representing the peaks of bow spray blisters at the various speeds. At low speeds, the pilot had no lateral control and the airplane heeled so that one or the other of the wing-tip floats was in the water. On the wing-high side no spray entered the propeller. On the wing-low side, although spray entered the propeller and struck the flap, this spray was considered moderate. The photographs of figure 18 show the difference in the spray on the two sides due to heel.

Rough-water behavior.- Although no extended investigation in rough water was intended, a few take-offs and landings were made in waves as a qualitative check on the airplane's behavior. The waves, which formed a confused pattern, were estimated by observers to be 18 to 24 inches high and 20 to 25 feet long with an accompanying maximum wind velocity of 23 miles per hour. Three landings were made, all on the verge of stall. The first, made into the waves, was quite severe with a maximum recorded normal acceleration of 2.5g which occurred on the first impact. A time history of this landing is given in figure 20. The other two landings, which were made parallel to the wave crests, were not quite so violent, the maximum recorded normal acceleration being 2.1g in each case and occurring on the first impact. Two successful upwind take-offs were made in the rough water; a time history of one is shown in figure 21. Three other take-offs had to be abandoned because of severe bouncing. Take-off attempts made in a direction parallel to the wave crests resulted in especially large motions about all three axes because of the confused wave pattern and the short, steep waves. The airplane taxied well upwind and downwind, although the nose buried a few times on the upwind heading. Crosswind taxying caused the downwind tip float to bury. As the severity of the wind and waves was increasing throughout the flight, the airplane was finally taxied to quieter water for the final take-off. Inspection revealed severe damage to the left tip float, moderate damage to the right tip float, the tail-wheel doors broken open, and moderate damage to the forebody bottom, sides, and frames just forward of the step. The decision was made to terminate the tests of the XP5M-1 hull at this point.

CONCLUDING REMARKS

Hydrodynamic qualities established in the flight investigation of the modified Navy J4F-2 airplane with the 0.425-scale XP5M-1 hull bottom may be summarized as follows:

1. The maximum up-elevator deflection usable for take-off was limited by abrupt pitch upward at getaway rather than by upper-limit porpoising.

2. The minimum up-elevator deflection usable for take-off was limited near getaway by directional instability at low trims rather than by lower-limit porpoising.

3. The take-off times ranged from 25 to 45 seconds. Between hump speed and getaway the average acceleration was approximately 2 feet per second per second.

4. No severe skipping on landing was encountered at any landing trim or center-of-gravity position in the operating range. There was, however, an objectionable tendency to trim down and yaw immediately after contact.

5. The rate of turn at maneuvering speeds was low.

6. During take-off in light winds a large amount of right rudder and differential power were required at speeds just beyond hump speed to maintain a straight course.